Planetary Instrument Concepts For The Advancement Of Solar System Observations

Miniaturized solid-state based vector magnetometer for planetary field mapping

Completed Technology Project (2016 - 2019)

Project Introduction

We propose a new solid-state magnetometer for planetary magnetic field measurements. The resulting instrument would be extremely compact and able to operate in harsh thermal and radiation environments. The proposed technology monitors magnetic field dependent changes in current measured from a silicon carbide (SiC) diode. These changes in current result from the external magnetic field interaction with unpaired electrons that reside within atomic scale defects intrinsic to the SiC material system. Additionally, the technology is simple to implement and does not utilize high frequency RF or optical circuitry which require stable temperatures for operation. Theoretically, this technology has the potential to compete with the sensitivity of heritage instruments while its solid-state nature allows the design to be made significantly smaller, lighter, and less expensive than current flight magnetometers. The science community has identified a strong need for scientific instruments which address the crosscutting themes of planetary science, these being building new worlds, planetary habitats, and workings of the solar systems. Magnetometers are very useful for addressing aspects of all of these themes by remotely probing the interior of a planet or satellite without the need invasively penetrate the body being investigated. These magnetic field measurements can be used to help better understand the internal workings of planets and their moons and can also be used in conjunction with simulations and models to shed much insight into the predictive formation and evolution of planets, satellites, and even the solar system. Magnetometers also aid in searching for the requirements of life. Magnetic field measurements allow for a better understanding of planetary atmospheres and their interaction with the solar wind which influences climate and the ability to harbor life. Also, magnetic field measurements have shown to be useful for indirect detection of planetary oceans as was done for Europa from the magnetometer on the Galileo spacecraft. Not only is this technology applicable to planetary science, but it also has much value in Earth Science and Heliophysics. As magnetic fields are everywhere in space and are associated with many scientific phenomena, there are many relevant mission opportunities for this instrument, ranging from the large flagship missions to the smaller New Frontiers and Discovery missions. This technology could enable a variety of magnetic field sensing applications, including planetary entry probes, landers, missions in extreme environments like Venus, and in swarms of spacecraft significantly smaller than current nanosats. The two most widely used magnetometers flown in space are fluxgate and optically pumped atomic gas. These instruments are mostly used because of their reliability, proven performance, and ability to satisfy constraints imposed by strict mission requirements. With the recent developments in semiconductor technology, we propose to further the development of a magnetometer which uses a single solid-state SiC diode as the magnetic field sensing medium. This technology can in theory compete with the sensitivity of heritage designs, but can be made significantly smaller, and requires very simple support electronics. In this work, we will first study the performance of a range of

Image Not Available

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Organizational Responsibility

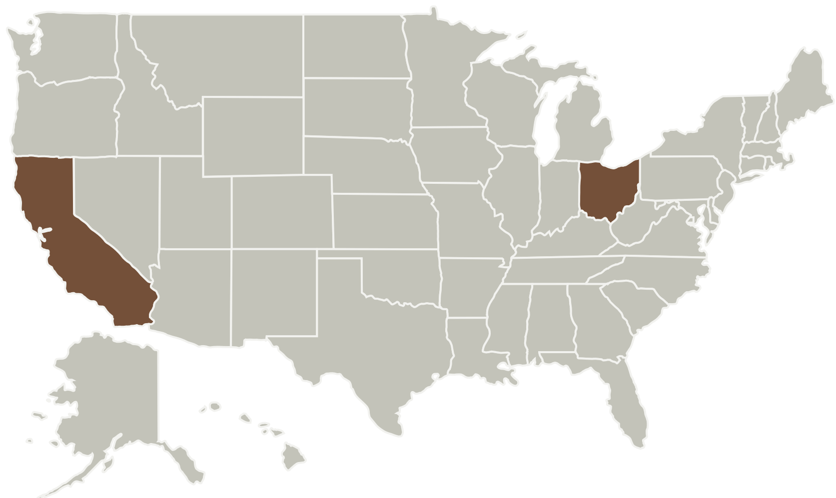
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Instrument Concepts for the Advancement of Solar System Observations preexisting diodes, received from a variety of SiC processing facilities, to determine the parameters that lead to the best performing sensor. Once the optimal processing conditions and parameters are determined, we will use this information along with defect engineering practices to fabricate a new SiC device that has performance tailored for precise and accurate magnetic field sensing. We will then integrate the new sensor into our existing magnetometer and test performance. In parallel, we will develop improved analog circuitry and signal processing software to optimize the sensitivity and stability of the magnetometer.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations	
California	Ohio

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

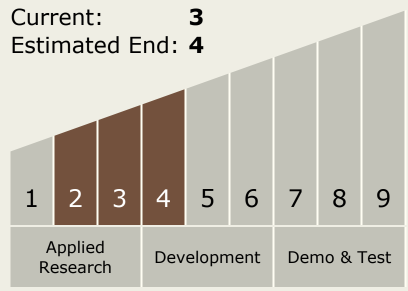
Corey J Cochrane

Co-Investigators:

Yuki Maruyama
Karen R Piggee
Philip G Neudeck
Neil Murphy
Jordana Blacksberg
Carol A Raymond

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.3 In-Situ Instruments and Sensors

Continued on following page.

Technology Areas *(cont.)*

└─ TX08.3.1 Field and Particle Detectors

Target Destination

Others Inside the Solar System